DEPARTMENT OF ECOLOGY

November 15, 2013

TO: Dave Bradley, Section Manager, TCP

FROM: Arthur Buchan, Toxicologist, TCP

SUBJECT: Dioxin/Furan/PCB (Ecological Risk Calculation Methodology)

The purpose of this memorandum is to document an interpretation from the Department of Ecology regarding the different procedures that should be used to calculate site contaminant levels for the Terrestrial Ecological Evaluation (MTCA WAC 173-340-7490 through 7494) (Ecology, 2007a) for:

- Chlorinated dibenzo-p-dioxins (PCDDs); TCDD is a member of this class,
- Chlorinated dibenzofurans (PCDFs); and
- Polychlorinated biphenyls (PCBs) - Both total PCBs and dioxin-like PCBs

The calculated contaminant levels are to be used for ecological screening level and cleanup purposes. This memorandum is specific as it pertains to Ecological Risk Assessment and the Terrestrial Ecological Evaluation (WAC 173-340-7490 through 7494) (Ecology, 2007a).

CALCULATING DIOXIN/FURAN/PCB LEVELS FOR COMPARISON WITH SCREENING VALUES AND FOR CLEANUP PURPOSES

Dioxin/Furans: Polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran congeners (dioxins and furans) are generally present in the environment as a complex mixture of chemical "congeners" that differ in terms of the number and location of chlorine atoms. 2,3,7,8 – Tetrachlorodibenzo-p-dioxin (TCDD) is the most toxic and best studied of the 210 dioxin and furan congeners (Ecology, 2007b). Scientists have concluded that the 17 dioxin/furan congeners identified in MTCA act through a common biological mechanism and essentially behave like one chemical. Because dioxins and furans are generally present in the environment as complex mixtures of chemical "congeners," scientists have developed the TEF methodology to evaluate the toxicity and assess the risks associated with the whole mixture. In this method, each congener is assigned a TEF value. The TEF is the ratio of the estimated toxicity for a particular congener to the toxicity demonstrated by 2,3,7,8 Tetrachlorodibenzo-p-dioxin (TCDD) (Ecology, 2007c). The TEF approach is based on the concept that the various congeners of dioxin/furan essentially act as one chemical, affecting the Ah receptor (Aryl Hydrocarbon Receptor).

Please note that that even though MTCA (Terrestrial Ecological Evaluation) has established separate screening levels for dioxins and furans, they (dioxins and furans) are treated as one mixture for the purposes of calculating and comparing to cleanup levels when Table 749-2 or 749-3 are not used. As a result, the process for calculating site contaminant levels for dioxins and furans to be <u>used for comparison with screening levels</u> (MTCA Table 749-2 or MTCA Table 749-3) is different from the approach <u>used for calculating protective cleanup levels</u> when MTCA Table 749-2 or Table 749-3 are not used.

PCBs: Polychlorinated biphenyl (PCBs) is a group of synthetic organic chemicals that include 209 individual chlorinated biphenyl compounds. Commercial mixtures of PCBs were manufactured in the United States from (approximately) 1930 to 1977 under the trademark "Aroclor" followed by a four digit number; usually the first two digits indicate the parent biphenyl molecule and the last two digits indicate the percent chlorine by weight. PCBs were used as coolants and lubricants in electrical equipment, such as capacitors and transformers, because of their inflammability, chemical stability, and insulating properties (Ecology, 2007b). In addition, PCBs have been produced worldwide until recently and can be found in ink, paint, caulks, newsprint, etc… MTCA (Terrestrial Ecological Evaluation) has established two general approaches for evaluating the ecological risks associated with environmental concentrations of PCBs: Total PCB concentration or Congener Specific Analyses.

Figure 1: Chemical structure of PCDDs (dioxins), PCDFs (furans), and dioxin-like PCBs. Numbers by aromatic ring carbons in general structures represent potential chlorine substitutions (USEPA, 2008).
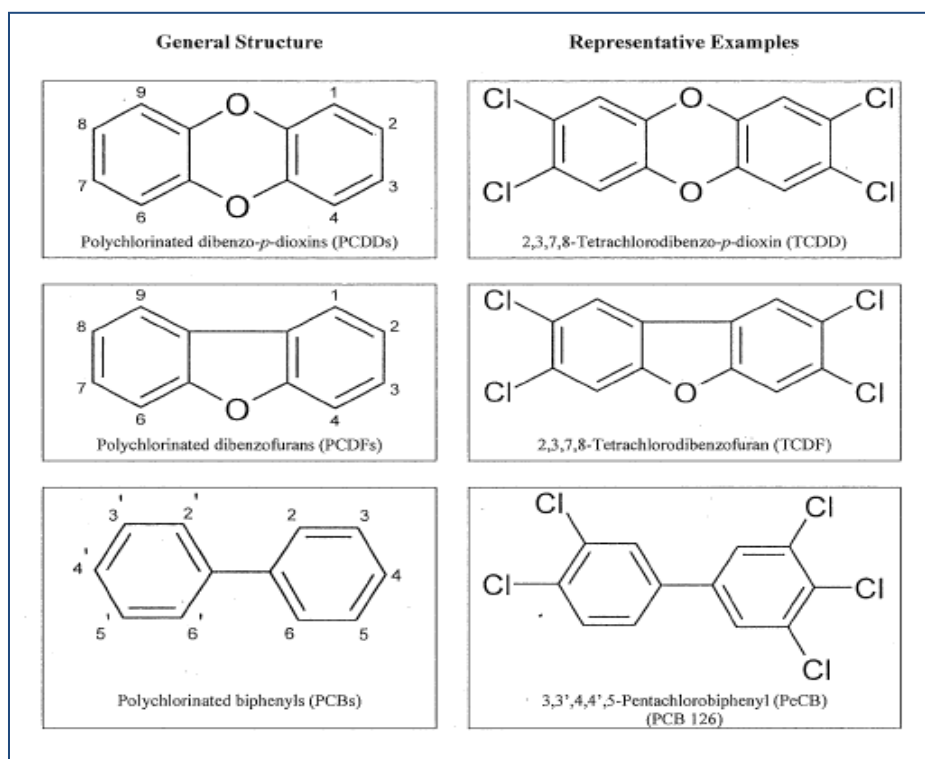
Aryl Hydrocarbon Receptor: The Aryl Hydrocarbon receptor (Ah receptor) is the common mode of action (Biological Mechanism) to which the 29 dioxin like (7 dioxin, 10 furan, and 12 PCB) congeners act upon. [Figure 2] demonstrates how the dioxin like congener enters the body through the bloodstream, binds with the Ah receptor, and then how the protein dioxin complex then binds to the strands of DNA (switching certain genes on and off), causing the toxic response (BEC, 2012).

Figure 2: Illustration of the toxic response created by any of the [29] dioxin-like congeners (BEC, 2012).
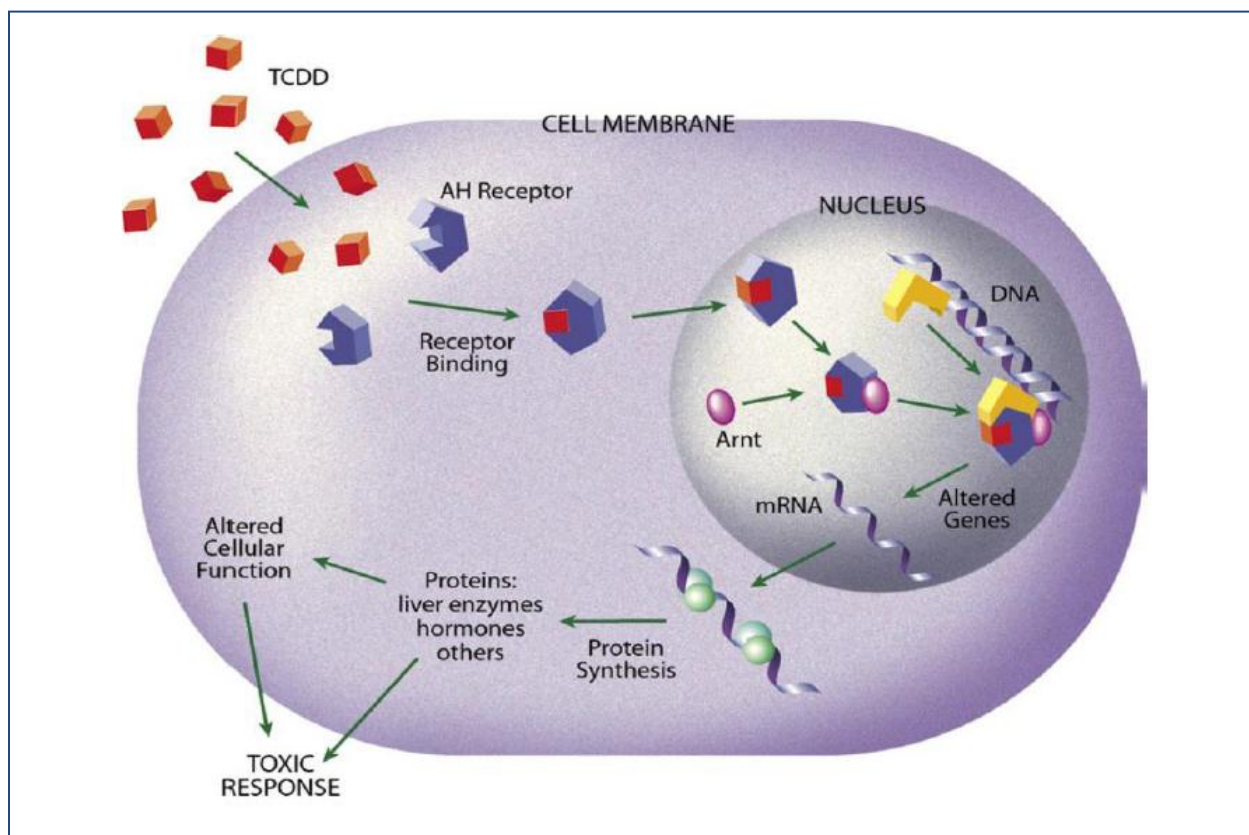
The screening levels (ecological risk assessment) for dioxins, furans, and PCBs that are included in the Terrestrial Ecological Evaluation (TEE) (WAC 173-340-7490 through 7494) are:

Figure 3: TEE Screening Levels for Dioxins, Furans, and PCBs.

Contaminant	**TEE - Simplified Evaluation (Table 749-2)**
Chlorinated dibenzofurans (total)	3E-06 mg/kg
Chlorinated dibenzo-p-dioxins (total)	5E-06 mg/kg
PCB mixtures (total)	2 mg/kg
	(Above Levels are for both Unrestricted and Ind./Comm. Land Use)
Contaminant	**TEE - Site-Specific Evaluation (Table 749-3)**
Chlorinated dibenzofurans (total)	(Wildlife = 2E-06 mg/kg)
Chlorinated dibenzo-p-dioxins (total)	(Wildlife = 2E-06 mg kg)
PCB mixtures	(Plants = 40 mg/kg) (Wildlife = 0.65 mg/kg)

TEF METHODOLOGY FOR ECOLOGICAL RISK ASSESSMENT

Toxic Equivalency Factors (TEF's) are used to convert Dioxin, Furan, and PCB congener data to Toxic Equivalency Quotients (TEQ's). Dioxin, Furan, and PCB TEQ's are then used to compare site data to screening levels or to establish protective cleanup levels. Mammalian TEF's should be used only for calculating TEQs for the mammalian predators (shrew) and mammalian herbivores (vole). Avian TEF's should be used for calculating TEQs for the avian predators (robin). Please see the TEF Table below for a complete summary of TEF values to be used for Ecological Risk Assessment. Either direct comparison or statistical methods (as described in WAC 173-340-740 (7)) shall be used for compliance sampling or monitoring.

Figure 4: PCDD, PCDF, and PCB TEFs for Mammals and Avians.

CAS Number	Hazardous Substance	Mammalian TEF[1]*	Avian TEF[1]
Dioxin Congeners			
1746-01-6	2,3,7,8-Tetrachloro dibenzo-p-dioxin	1	1
40321-76-4	1,2,3,7,8-Pentachloro dibenzo-p-dioxin	1	1
39227-28-6	1,2,3,4,7,8-Hexachloro dibenzo-p-dioxin	0.1	0.05
57653-85-7	1,2,3,6,7,8-Hexachloro dibenzo-p-dioxin	0.1	0.01
19408-74-3	1,2,3,7,8,9-Hexachloro dibenzo-p-dioxin	0.1	0.1
35822-46-9	1,2,3,4,6,7,8-Heptachloro dibenzo-p-dioxin	0.01	<0.001
3268-87-9	1,2,3,4,6,7,8,9-Octachloro dibenzo-p-dioxin	0.0003	0.0001
Furan Congeners			
51207-31-9	2,3,7,8-Tetrachloro dibenzofuran	0.1	1
57117-41-6	1,2,3,7,8-Pentachloro dibenzofuran	0.03	0.1
57117-31-4	2,3,4,7,8-Pentachloro dibenzofuran	0.3	1
70648-26-9	1,2,3,4,7,8-Hexachloro dibenzofuran	0.1	0.1
57117-44-9	1,2,3,6,7,8-Hexachloro dibenzofuran	0.1	0.1
72918-21-9	1,2,3,7,8,9-Hexachloro dibenzofuran	0.1	0.1
60851-34-5	2,3,4,6,7,8-Hexachloro dibenzofuran	0.1	0.1
67562-39-4	1,2,3,4,6,7,8-Heptachloro dibenzofuran	0.01	0.01
55673-89-7	1,2,3,4,7,8,9-Heptachloro dibenzofuran	0.01	0.01
39001-02-0	1,2,3,4,6,7,8,9-Octachloro dibenzofuran	0.0003	0.0001
PCB Congeners			
32598-13-3	3,3',4,4' TetraCB (77)	0.0001	0.05
70362-50-4	3,4,4',5 TetraCB (81)	0.0003	0.1
32598-14-4	2,3,3',4,4' PeCB (105)	0.00003	0.0001
74472-37-0	2,3,4,4',5 PeCB (114)	0.00003	0.0001
31508-00-6	2,3',4,4',5 PeCB (118)	0.00003	0.00001
65510-44-3	2',3,4,4'5 PeCB (123)	0.00003	0.00001
57465-28-8	3,3'4,4',5 PeCB (126)	0.1	0.1
38380-08-4	2,3,3',4,4',5 HxCB (156)	0.00003	0.0001
69782-90-7	2,3,3',4,4',5' HxCB (157)	0.00003	0.0001
52663-72-6	2,3',4,4',5,5' HxCB (167)	0.00003	0.00001
32774-16-6	3,3',4,4',5,5' HxCB (169)	0.03	0.001
39635-31-9	2,3,3',4,4',5,5' HpCB (189)	0.00003	0.00001

1   **Source:** Van den Berg et al. 2006. The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxicity Equivalency Factors for Dioxins and Dioxin-like Compounds. Toxicological Sciences 2006 93(2):223-241; doi:10.1093/toxsci/kfl055.

*   **Editor's Note:** Abbreviated the term "Toxicity Equivalency Factor" used in the adopted rule for purpose of brevity and consistency with other tables in WAC 173-340-900.

SUMMARY OF TEF METHODOLOGY
SUMMARY OF CALCULATING DIOXIN, FURAN, AND DIOXIN – LIKE PCBs FOR COMPARISON WITH TABLE 749-2 OR 749-3

From a toxicological point of view, any level set should apply to all dioxin like-dioxins, furans, and PCBs, but in 2001 there was very limited data available on the prevalence of dioxin-like PCBs. Since 2001, more data on the presence of dioxin-like PCBs have become available; therefore maximum levels for the sum of [dioxins and dioxin – like PCBs] have been set in 2006 as this is the most appropriate approach (Gueguen et al., 2011). From current toxicological methods used to evaluate the toxicity and assess the risk of complex chemical mixtures, it is recognized that any screening level intended to be protective of [Chlorinated dibenzo-p-dioxins (PCDDs), Chlorinated dibenzofurans (PCDFs), and Dioxin – like polychlorinated biphenyls (PCBs)] should encompass all three contaminants. The toxicity equivalency methodology is a tool for assessing the cumulative toxicity of a complex mixture of dioxin-like PCDDs, PCDFs, and PCBs (USEPA, 2008).
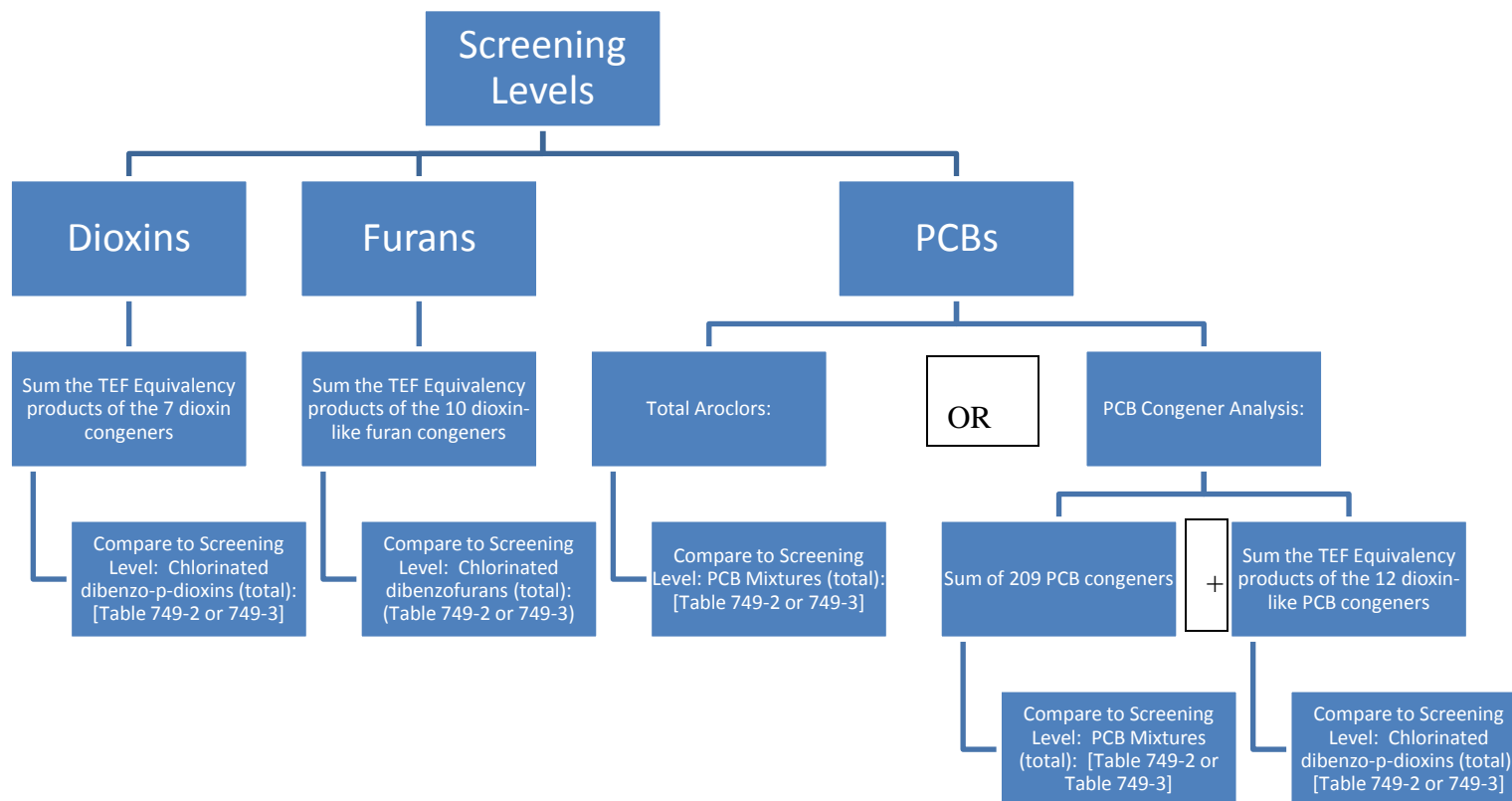
With that understanding, current MTCA regulations allow for the calculation of the individual contaminant (PCDDs, PCDFs, PCBs) mixtures to be compared to the screening levels listed in Table 749-2 or Table 749-3 to establish Contaminants of Ecological Concern (note that for cleanup purposes all dioxin like congeners should be included). If a contaminant is above the respective Table Level (Table 749-2 or Table 749-3), then cleanup levels should be set that would be protective of the ecological receptors as per WAC 173-340-7490 through 7494.

For Ecological Risk Assessment:

- The sum of the TEF equivalency [commonly referred to as the toxicity equivalency quotient (TEQ)] for the [7] dioxin congeners is compared to the appropriate screening level table (Table 749-2 or Table 749-3) for Chlorinated dibenzo-p-dioxins (total).

- The sum of the TEF equivalency for the [10] furan congeners is compared to the appropriate screening level table (Table 749-2 or Table 749-3) for Chlorinated dibenzofurans (total).

- If only concerned with total PCB concentrations, Total Aroclors could be compared to PCB mixtures (total) screening level table (Table 749-2 or Table 749-3).

- If using congener – specific analyses for PCBs (concerned with both total and dioxin – like PCBs), the sum of the [209] individual congeners should be compared to PCB mixtures (total) screening level table (Table 749-2 or Table 749-3). The sum of the TEF equivalency for the [12] dioxin – like PCB congeners should be compared to the appropriate screening level table (Table 749-2 or Table 749-3) for Chlorinated dibenzo-p-dioxins (total) [1].

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[1] The screening level for Chlorinated dibenzo-p-dioxin (total) was based off of a Bioaccumulation Factor (BAF) and Lowest Observed Adverse Effects Level (LOAEL) for the sentinel congener, 2,3,7,8 TCDD. Therefore, the PCB TEQ should be less than the total TEQ (which is the screening level for 2,3,7,8 TCDD).

Figure 5: Summary of Calculating Contaminant Levels for use with Screening to MTCA Table 749-2 or 749-3.


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                            Screening
                             Levels
        ┌─────────────────────┼──────────────────────────────┐
     Dioxins               Furans                          PCBs
        │                     │              ┌───────────────┴───────────────┐
Sum the TEF            Sum the TEF     Total Aroclors:      OR      PCB Congener Analysis:
Equivalency            Equivalency
products of the 7      products of the 10                        ┌──────────┴──────────┐
dioxin congeners       dioxin-like furan                  Sum of 209   +   Sum the TEF Equivalency
                       congeners                          PCB              products of the 12 dioxin-
        │                     │              │            congeners        like PCB congeners
Compare to            Compare to      Compare to              │                      │
Screening             Screening       Screening         Compare to            Compare to
Level: Chlorinated    Level: Chlorinated  Level: PCB    Screening             Screening
dibenzo-p-dioxins     dibenzofurans   Mixtures (total): Level: PCB            Level: Chlorinated
(total):              (total):        [Table 749-2 or   Mixtures             dibenzo-p-dioxins (total):
[Table 749-2 or       (Table 749-2 or 749-3]            (total): [Table      [Table 749-2 or 749-3]
749-3]                749-3)                            749-2 or
                                                        Table 749-3]
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**** Total Aroclors (EPA Method 8082) is acceptable when there are no suspected dioxin-like congeners at the site. PCB Congener Analysis (EPA Method 1668) should be used to evaluate PCB concentrations when there are suspected dioxin-like congeners at the site. ****

**PROCEDURES FOR CALCULATING DIOXIN AND FURAN LEVELS
(FOR COMPARISON WITH TABLE 749-2 OR 749-3)**

1. When establishing and determining compliance with screening levels, mixtures of dioxins should be considered a single hazardous substance and mixtures of furans should be considered another single hazardous substance.
    a. The Simplified Terrestrial Ecological Evaluation screening levels (MTCA Table 749-2) shall be used only at sites where it has been determined that a Simplified Terrestrial Ecological Evaluation (WAC 173-340-7492) will meet the Ecological Risk Assessment requirements of WAC 173-340.
    b. The Site-Specific Terrestrial Ecological Evaluation screening levels (MTCA Table 749-3) can be used at sites where it has been determined that either a Simplified or Site-Specific Terrestrial Ecological Evaluation (WAC 173-340-7492 or WAC 173-340-7493) will meet the Ecological Risk Assessment requirements of WAC 173-340.

2. Calculate the toxic equivalent concentration of each of the seven [7] dioxin congeners by multiplying the individual congener analytical results by the appropriate toxic equivalency factor (TEF). Sum the resulting calculations to determine a dioxin toxic equivalency quotient (TEQ).
    a. Review the Laboratory Quality Assurance Project Plan (QAPP) to verify that the Laboratory Quantitation Limit (PQL/EQL) for each dioxin-like congener (PCDD, PCDF, PCB) is at (or lower than) the Quantitation Limit established for each congener listed in the USEPA Method (Ecology, 2013).
    b. Laboratory PQL/EQLs are oftentimes much lower than what is required by the EPA method.
        i. Assignment of [½ the Detection Limit or 0] for censored values requires department approval. Verify the Laboratory can achieve department requirements for PQL/EQL (Ecology, 2013).
            1. Non-Detected congeners should be assigned a value of [½] the detection limit for compliance calculations only if the following three criteria have been met (Ecology, 2013):
                a. Congener is not detected in the sample of concern (EDL);
                b. Lab PQL/EQL detection limits are no greater than the PQL/EQL established by the USEPA Method; and
                c. The department does not require a lower quantitation limit as per WAC 173-340-830(2) (e).
            2. Non-Detected congeners could be assigned a value of [0] for compliance calculations only if the following three criteria have been met (Ecology, 2013):
                a. Congener is not detected in any sample at the site (EDL);
                b. Lab PQL/EQL detection limits are no greater than the PQL/EQL established by the USEPA Method; and
                c. The department does not require a lower quantitation limit as per WAC 173-340-830(2) (e).

3. Calculate the toxic equivalent concentration of each of the ten [10] furan congeners by multiplying the individual congener analytical results by the appropriate toxic equivalency factor (TEF). Sum the resulting calculations to determine a furan toxic equivalency quotient (TEQ).
    a. Review the Laboratory Quality Assurance Project Plan (QAPP) to verify that the Laboratory Quantitation Limit (PQL/EQL) for each dioxin-like congener (PCDD, PCDF, PCB) is at (or lower than) the Quantitation Limit established for each congener listed in the USEPA Method (Ecology, 2013).
    b. Laboratory PQL/EQLs are oftentimes much lower than what is required by the EPA method.

i. Assignment of [½ the Detection Limit or 0] for censored values requires department approval. Verify the Laboratory can achieve department requirements for PQL/EQL (Ecology, 2013).

1. Non-Detected congeners should be assigned a value of [½] the detection limit for compliance calculations only if the following three criteria have been met (Ecology, 2013):

    a. Congener is not detected in the sample of concern (EDL);
    b. Lab PQL/EQL detection limits are no greater than the PQL/EQL established by the USEPA Method; and
    c. The department does not require a lower quantitation limit as per WAC 173-340-830(2) (e).

2. Non-Detected congeners could be assigned a value of [0] for compliance calculations only if the following three criteria have been met (Ecology, 2013):

    a. Congener is not detected in any sample at the site (EDL);
    b. Lab PQL/EQL detection limits are no greater than the PQL/EQL established by the USEPA Method; and
    c. The department does not require a lower quantitation limit as per WAC 173-340-830(2) (e).

4. Compare the dioxin summed TEQ calculation with the appropriate table for Chlorinated dibenzo-p-dioxins (total) for a determination if dioxins are considered a Contaminant of Ecological Concern.

5. Compare the furan summed TEQ calculation with the appropriate table for Chlorinated dibenzofurans (total) for a determination if furans are considered a Contaminant of Ecological Concern.

PROCEDURES FOR CALCULATING DIOXIN/FURAN PROTECTIVE CLEANUP LEVELS
(OTHER THAN TABLE 749-2 OR 749-3)

1. When determining protective cleanup levels, the seven Chlorinated Dibenzo-p-Dioxin and ten Chlorinated Dibenzofuran congeners shall be considered a single hazardous substance. Through the use of TEF methodology that single hazardous substance shall be compared with a contaminant level determined to be protective for 2,3,7,8 – TCDD.
    a. The Simplified Terrestrial Ecological Evaluation screening levels (MTCA Table 749-2) shall be used only at sites where it has been determined that a Simplified Terrestrial Ecological Evaluation (WAC 173-340-7492) will meet the Ecological Risk Assessment requirements of WAC 173-340.
    b. The Site-Specific Terrestrial Ecological Evaluation screening levels (MTCA Table 749-3) can be used at sites where it has been determined that either a Simplified or Site-Specific Terrestrial Ecological Evaluation (WAC 173-340-7492 or WAC 173-340-7493) will meet the Ecological Risk Assessment requirements of WAC 173-340.
2. Calculate the toxic equivalent concentration of each of the seven [7] dioxin and ten [10] furan congeners by multiplying the individual congener analytical results by the appropriate toxic equivalency factor (TEF). Sum the resulting calculations to determine a dioxin/furan toxic equivalency quotient (TEQ).
    a. Review the Laboratory Quality Assurance Project Plan (QAPP) to verify that the Laboratory Quantitation Limit (PQL/EQL) for each dioxin-like congener (PCDD, PCDF, PCB) is at (or lower than) the Quantitation Limit established for each congener listed in the USEPA Method (Ecology, 2013).
    b. Laboratory PQL/EQLs are oftentimes much lower than what is required by the EPA method.
        i. Assignment of [½ the Detection Limit or 0] for censored values requires department approval. Verify the Laboratory can achieve department requirements for PQL/EQL (Ecology, 2013).
            1. Non-Detected congeners should be assigned a value of [½] the detection limit for compliance calculations only if the following three criteria have been met (Ecology, 2013):
                a. Congener is not detected in the sample of concern (EDL);
                b. Lab PQL/EQL detection limits are no greater than the PQL/EQL established by the USEPA Method; and
                c. The department does not require a lower quantitation limit as per WAC 173-340-830(2) (e).
            2. Non-Detected congeners could be assigned a value of [0] for compliance calculations only if the following three criteria have been met (Ecology, 2013):
                a. Congener is not detected in any sample at the site (EDL);
                b. Lab PQL detection limits are no greater than the PQL established by the USEPA Method; and
                c. The department does not require a lower quantitation limit as per WAC 173-340-830(2) (e).
3. Compare the complete dioxin/furan summed TEQ calculation with a dioxin/furan contaminant level calculated to be protective of ecological receptors through methods listed in WAC 173-340-7493(3)(a) through (g) [Selection of appropriate terrestrial ecological evaluation methods].

For protective cleanup levels other than Table 749-2 or 749-3 – If PCBs are a contaminant of ecological concern (and are calculated as Congener Specific Analysis), the sum of the 12 PCBs should be included in the dioxin/furan TEQ calculation (Van den Berg et al., 1998):

$$TEQ = \sum (PCDD_i \times TEF_i) + \sum (PCDF_i \times TEF_i) + \sum (PCB_i \times TEF_i)$$

Where:

- o PCDD = Polychlorinated dibenzo-p-dioxin
- o PCDF = Polychlorinated dibenzofuran
- o PCB = Polychlorinated biphenyl

PCB SUMMARY ANALYSIS

- Method 1668 for PCBs
  - Advantages:
    - It includes all 209 congeners
      - Allows for both total PCBs and calculation of the 12 dioxin-like congeners
    - Relatively low detection rates (ppt) – This is important when assigning [½ DL] for the non-detected dioxin-like congeners.
  - Disadvantages:
    - Relatively expensive (Check Laboratory Costs)
    - Not an included analytical testing method for soils under MTCA (shall comply with the following requirements for soil)
      - WAC 173-340-830(3) (a) (i) – Method 1. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, U.S. EPA, SW 846, fourth update (2000).
- Method 8082 for PCBs
  - Advantages:
    - It allows for testing both Total Aroclors and the 12 dioxin-like congeners (depending on the specific test chosen)
    - Relatively inexpensive: (Check Laboratory Costs) for total Aroclors, (Check Laboratory Costs) for the limited congener specific analysis
      - The limited congener specific analysis should give you both dioxin-like PCBs and the (limited) 60 congeners (total)
    - Meets the analytical testing method for soils testing under MTCA
      - It is included under SW 846
  - Disadvantages:
    - Laboratory detection limit is much higher than Method 1668 (ppb vs. ppt). This is important for censored values and the dioxin-like congeners because PQLs do not allow for determination at the ppt level.

From an ecological risk standpoint, the department (Ecology) can require additional measures under WAC 173-340-7490 (5). This would allow Ecology…. "… to evaluate potential threats to terrestrial ecological receptors notwithstanding in this and the following sections, when based upon a site-specific review, the department determines that such measures are necessary to protect the environment." The potential additive risk for dioxin-like congeners (7 dioxins, 10 furans, and 12 PCBs) warrants the use of this additional measures citation under the regulation.

- As a result, it is reasonable for site managers to require Method 1668 (full congener-specific analysis [209 congeners]) for PCBs to be run when testing for PCBs when it is suspected that dioxin-like congeners are present at a site under WAC 173-340-7490(5). This should account for the additive risk of dioxin-like PCB congeners.
- If dioxin-like congeners are not suspected to be present at a site, then Method 8082 (total Aroclors) should be an appropriate method for testing for PCB mixtures (total).

PROCEDURES FOR CALCULATING PCB LEVELS

There are two general approaches for evaluating the ecological risks associated with environmental concentrations of PCBs:

1. <u>Total PCB Concentration Method 8082 (when dioxin-like congeners are not suspected at a site):</u> Under the MTCA Cleanup Regulation, calculating site contaminant levels for use with comparing to screening levels (Table 749-2 and Table 749-3) for PCB mixtures can be calculated using measurements of total PCB concentrations in environmental media using standard methods that involve the use of gas chromatography/electron capture detection systems. Specifically, total PCB concentrations are estimated by comparing the chromatographic pattern of peaks in the environmental sample with the pattern or number of peaks in a commercial Aroclor sample. Using this approach, total Aroclors would be compared with the PCB mixtures (total) screening level to determine if PCBs are a contaminant of ecological concern.

2. <u>Congener Specific Analyses Method 1668 (when dioxin-like congeners are suspected at a site):</u> PCB mixtures may include up to 209 individual congeners which differ in terms of the number and location of chlorine atoms. Over the last 30 years, the standard approach for estimating PCB environmental concentrations has begun to shift from the analysis of commercial mixtures (Aroclors-listed above) to congener-based analyses. Dioxins and furans are generally present in the environment as complex mixtures of chemical "congeners" that differ in terms of the number and location of chlorine atoms. Using this approach, the PCB summed TEQ calculation would be compared to the appropriate Chlorinated dibenzo-p-dioxins (total) screening level to determine in PCBs are a contaminant of ecological concern:

   a. When establishing and determining compliance with both screening and protective cleanup levels, mixtures of PCBs shall be considered a single hazardous substance.
      i. The Simplified Terrestrial Ecological Evaluation screening level (MTCA Table 749-2) for PCB mixtures (total) (2mg/kg), and Chlorinated dibenzo-p-dioxins (total) (5E-06 mg/kg) shall be used to screen for PCBs (on a congener-specific analyses) only at sites where it has been determined that a Simplified Terrestrial Ecological Evaluation (WAC 173-340-7492) will meet the Ecological Risk Assessment requirements of WAC 173-340.
      ii. The Site-Specific Terrestrial Ecological Evaluation screening levels (MTCA Table 749-3) for PCB mixtures (total) (40 mg/kg – plants, 0.65 mg/kg – wildlife), and Chlorinated dibenzo-p-dioxins (total) (2E-06 mg/kg – wildlife) shall be used to screen for PCBs (on a congener-specific analyses) at sites where it has been determined that either a Simplified or Site-Specific Terrestrial Ecological Evaluation (WAC 173-340-7492 or WAC 173-340-7493) will meet the Ecological Risk Assessment requirements of WAC 173-340.
   b. Calculate total PCBs by summing the [209] individual congeners; and
   c. Calculate the toxic equivalent concentration of each of the [12] dioxin – like PCB congeners by multiplying the individual congener analytical results by the appropriate toxic equivalency factor (TEF). Sum the resulting calculations to determine a PCB toxic equivalency quotient (TEQ).
      i. Review the Laboratory Quality Assurance Project Plan (QAPP) to verify that the Laboratory Quantitation Limit (PQL/EQL) for each dioxin-like congener (PCDD, PCDF, PCB) is at (or lower than) the Quantitation Limit for each congener listed in the USEPA Method (Ecology, 2013).
      ii. Laboratory PQL/EQLs are oftentimes much lower than what is required by the EPA method.

1. Assignment of [½ the Detection Limit or 0] for censored values requires department approval. Verify the Laboratory can achieve department requirements for PQL/EQL.
   a. Non-Detected congeners should be assigned a value of [½] the detection limit for compliance calculations only if the following three criteria have been met (Ecology, 2013):
      i. Congener is not detected in the sample of concern (EDL);
      ii. Lab PQL/EQL detection limits are no greater than the PQL/EQL established by the USEPA Method; and
      iii. The department does not require a lower quantitation limit as per WAC 173-340-830(2) (e).
   b. Non-Detected congeners could be assigned a value of [0] for compliance calculations only if the following three criteria have been met (Ecology, 2013):
      i. Congener is not detected in any sample at the site (EDL);
      ii. Lab PQL/EQL detection limits are no greater than the PQL/EQL established by the USEPA Method; and
      iii. The department does not require a lower quantitation limit as per WAC 173-340-830(2) (e).

d. PCB calculations:
   i. Screening Purposes (PCB [total]): Compare the complete PCB summed (total) calculation with the appropriate table (Table 749-2 or Table 749-3) for PCB mixtures (total) for a determination if PCBs are considered a Contaminant of Ecological Concern.
   ii. Screening Purposes (PCB TEQ): Compare the complete TEQ calculation with the appropriate table (Table 749-2 or 749-3) for Chlorinated dibenzo-p-dioxins (total) for a determination if dioxin – like PCBs are considered a Contaminant of Ecological Concern.
   iii. Protective Cleanup Levels (PCB [total]) (other than table values): Compare the complete PCB summed (total) calculation with the appropriate table (Table 749-2 or Table 749-3), or through using methods listed in WAC 173-340-7493(3) (a) through (g) [selection of appropriate terrestrial ecological evaluation methods].
   iv. Protective Cleanup Levels (PCB TEQ) (other than table values): Compare the complete PCB summed TEQ calculation with a dioxin/furan contaminant level calculated to be protective of ecological receptors through methods listed in WAC 173-340-7493(3)(a) through (g) [Selection of appropriate terrestrial ecological evaluation methods].

For protective cleanup levels other than Table 749-2 or 749-3 – If PCDDs and/or PCDFs are contaminants of concern the sum of the dioxin-like congeners that have been screened as contaminants of ecological concern should be included in the PCB TEQ calculation (Van den Berg et al., 1998):

$$TEQ = \sum (PCDD_i \times TEF_i) + \sum (PCDF_i \times TEF_i) + \sum (PCB_i \times TEF_i)$$

Where:

- PCDD = Polychlorinated dibenzo-p-dioxin
- PCDF = Polychlorinated dibenzofuran
- PCB = Polychlorinated biphenyl

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